PATENT SPECIFICATION

DRAWINGS ATTACHED

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Blading for axial flow turbines.

COMPLETE SPECIFICATION

We, AKTEINGESELLSCHAFT BROWN, BOVERI & CIE., of Badan, Switzerland, a Swiss Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Turbine blades whose angles particularly at the steam or gas outlet side vary along the length of the blades are designed as "twisted blades". Long blades, for instance those which are longer than a tenth part of the mean blading diameter, are usually twisted so that the blade angle suits the flow directions which occur at various peripheral speeds along the blade, whereby good efficiences are obtained.

The known principles in accordance with which the blades of a turbine stage are as follows: The greater the distance from the rotor axis at which the flow is observed the smaller is the change in the tangential component of the flow velocity, because the product of this change in tangential component and of the radius is constant along the blade length. The blades must therefore be constructed for this variable tangential component. Even when this is done there is still a certain freedom. The law concerning the change in the tangential component gives information about the difference between the tangential components in front of and after the blade row, but not about the actual velocity. Thus one of the two, for instance the velocity of the steam leaving the guide blade row and its variation along the length of the blade, can be selected as desired. Also the axial component and its variation along the length of the blade can be selected as desired within certain limits. Generally there is no reason to depart appreciably from a constant axial velocity along the length of the blade.

In present-day practice generally one of the two following methods is preferred:—

1. The outlet angles of the guide and moving blades are kept constant along the blade length. The inlet angles are either adapted to suite the fluid flow direction or the blade is not twisted and instead its inlet edge is rounded off so that it adapts itself to the various incoming flow directions.

2. The blades are twisted in such a manner that after the guide blade row the product of the tangential velocity of the flow and of the radius for various points along the length of the blade remains constant As a consequence of this the product of the absolute tangential velocity and of the radii remain constant also after the moving blade rows. Such a flow is termed eddy-free. It possesses the advantage that it can very easily be calculated and is free from certain secondary currents.

Whilst in the first case the blade outlet angles throughout the length of the blades remain constant, in the second case the outlet angle of the guide blades increases from their inner end to their outer end the fluid outlet angle of the guide blades decreases and that of the moving blades increases.

This twisting which is contrary to the usual form appears at first sight to be unnatural and has therefore to be justified. The heat drop (enthalpy drop) is either uniformly or non-uniformly distributed on the guide row and on the moving blade row of a turbine stage. The ratio of these partial heat drops is determined mainly by the ratio of the cross-sectional areas of flow of the guide and moving blade rows which in turn again depends on the blade outlet angle. If for instance both flow areas are equal, the heat drop will be equally distributed over both blade rows. The ratio of the heat drop in the moving blade row to the drop in the stage is called the degree of reaction and lies between 0 and 1 and in

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the above case amounts to 0.5.

It has been found that the degree of reaction is of very considerable importance in connection with certain energy losses which can occur at the blade ends. At the outer circumference between the moving blades or the shrouding that surrounds them and the guide blade carrier there must be a running clearance. Steam or gas flows through this gap without doing any work, the flow being all the greater the greater the heat drop in the moving blade row. The fixed guide blades have no clearance at the outer diameter and therefore no such loss. As a result it is an advantage to have as much heat drop as possible at the fixed blades at the outer diameter and as little as possible at the outer diameter of the moving blades, that is to say the degree of reaction of the stage should be made small—in the extreme case zero.

At the inner diameter of the blades conditions are just the reverse. Between the guide blades and the rotor a running clearance is necessary, but not at the foot of the moving blades. Thus, it is an advantage to have as small a heat drop as possible at the inner diameter of the guide blades, that is to say as large a degree of reaction as possible, namely 1 in the limiting case.

With untwisted blades the degree of reaction along the blades of a stage is approximately constant. With blading which is twisted in the usual manner, namely with blade outlet angles which increase from the inner end to the outer end of the guide blades and decrease on the moving blades, the degree of reaction increases from the inside to the outside, that is to say just in an opposite manner to that which would be favourable from a running clearance loss standpoint. If, however, the blades are twisted in a manner which is just contrary to that which is usual, the degree of reaction decreases from the inside to the outside, that is it changes in a manner which is favourable as regards reducing the clearance losses.

The reason for twisting the blades is now no longer the difference in peripheral velocity at various diameters but in order to reduce the leakage losses at the blade ends. It is therefore also expedient to twist the blade not only when they are long with respect to the mean diameter of the blading, but also when they are short, for example shorter than one tenth of the said mean diameter. With short blades this is particularly the case, because the leakage losses, which it is the object to diminish, are more noticeable with short blades than with long ones. However, they must not be too short, because radial displacements will occur in the flow which counteract the changes in the degree of reation which it is intended to achieve. The ratio of blade length to blade width should therefore amount to at least 1.5.

The accompanying diagrammatic drawings shows the blades of one stage, namely of a guide blade row and of a moving blade row of the decribed blading, Figure 1 shewing a longitudinal section of these blade rows, taken along an axial plane, whilst Figure 2 is a cross-sectional view of some of the blades of both rows taken on the plane II—II of Figure 1 and Figure 3 a cross-sectional view of the same blades taken along the plane III—III of Figure 1.

In Fiure 1 reference numeral 1 indicates part of a guide blade carrier and 2 part of the rotor of the turbine, 3 being a guide blade which is held in the blade carrier by its root 4. 5 is a moving blade whose root 6 is held in the rotor. 7 is shrouding for the guide blades which as shown at 8 has a running clearance with respect to the rotor. 9 is shrouding for the moving blades which as shown at 10 have a running clearance with respect to the guide blade carrier. The blades need not necessarily be provided with a shrouding. Their tips, preferably sharpened, can simply have a clearance with respect to the opposing part.

In Figures 2 and 3, reference numeral 3 again indicates the guide blades and 5 the moving blades. 11, 12, 13 and 14 are outlet angles of the blades at the points in question. In accordance with the preceding description angle 11 is smaller than angle 12 whilst angle 13 is greater than angle 14. In this way the pressures prevailing at the inlet side of the clearances 8 and 10 are diminished and the leakage losses which occur at these clearances are reduced.

WHAT WE CLAIM IS:—

1. Blading for axial flow turbines, characterised by the feature that over the blade length from the inner end to the outer end the fluid outlet angle of the guide blades decreases and that of the moving blades increases.

2. Blading for axial flow turbines, substantially as described above with reference to the accompanying diagrammatic drawings.

MARKS & CLERK.
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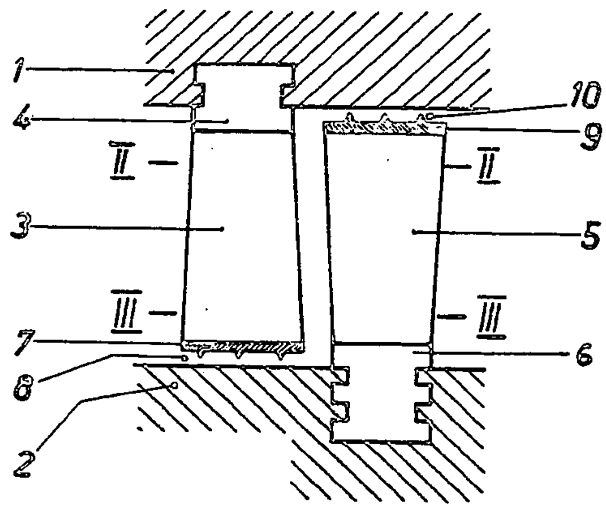

Fig. 1

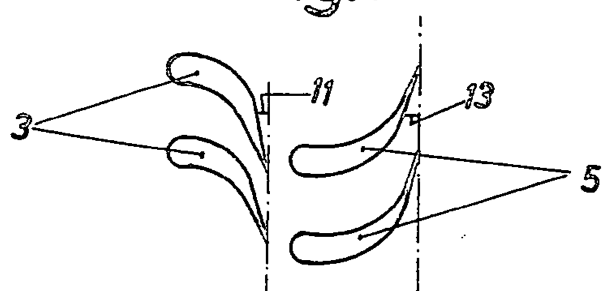

Fig. 2

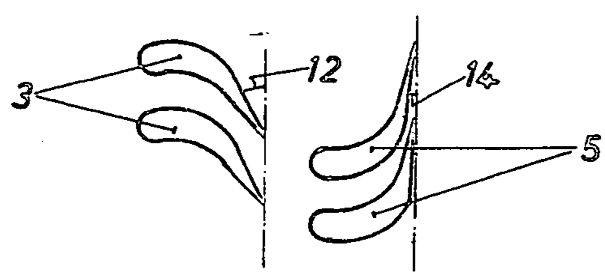

Fig. 3